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SYSTEMS ANALYSIS: PROBLEMS, PROGRESS, AND POTENTIAL

by

Thomas C. Rowan

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SYSTEM DEVELOPMENT CORPORATION
2500 COLORADO AVE.
SANTA MONICA
CALIFORNIA
90406

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ABSTRACT

This paper discusses the application of system analysis techniques to the mounting socioeconomic problems of urban areas. Several specific projects are described including: the applications in management information, crime and delinquency, waste management, transportation, education, document handling, urban and regional affairs and long-range planning. Several operational problems encountered in the course of the studies are reviewed.

SYSTEMS ANALYSIS IN SOCIETY

Systems Analysis is a term with many meanings. Basically, it is a set of techniques used widely for management decision-making, planning, and the design of "things" - ranging from military weapons systems to school scheduling.

Apart from its "conventional" applications in sophisticated weapon and space systems development, the aerospace industry is finding new uses for systems analysis in attacking the socioeconomic problems of the nation's heavily populated states and cities.

The central idea of the systems analytic approach is that functional components are interrelated and that a complex process can be understood best if it is treated as a whole. Although single components of a system may be improved, the best results are obtained when the system is seen in total perspective and the interrelationship of its parts understood.

This approach views a system in the broadest possible perspective - including the system's surrounding social and economic environment, and it pays very close attention to the information network binding the interacting elements of the system together.

Shorn of the mystique sometimes surrounding it, systems analysis seems nothing more or less than a methodology to attack a complex problem using a very specific attitude or intent on the one hand, and on the other, an aggregation of techniques utilized in conjunction with the scientific method. The attitude or intent of the researcher is to be as broad and all-encompassing in the data he gathers and as objective as possible in the evaluation of the data.

Basically, the process of systems analysis implies a sequence of activities including:

1. A definition and detailed description of the boundaries of the system. (An example could be the system of criminal justice in California.)

2. A functional description of the system in terms of the component subsystems and their operational interactions. (This would include descriptions of the activities of the police, courts, and correction facilities at both the state and county levels, and the interface with other organizations such as the Department of Welfare, Department of Health, and the State Legislature.)

3. The determination of objectives and criteria of optimal system performance. (This is a critical step in which the users of the system, such as, in the case of the above example, the Department of Justice, the Youth and Adult Corrections Agency, and various police agencies, must be willing to participate by detailing the goals and objectives they wish the system to achieve.)

4. An examination of reasonable alternative configurations of the system elements that approximate optimal system performance and the determination of the consequences of each configuration in terms of feasibility, acceptability, and cost-effectiveness. (One might, for example, propose that the California system of medium security correctional facilities be abolished, possibly at a great reduction in cost. While alternate methods make this plan technically feasible, the proposal would be unacceptable to a sufficient number of legislators, prison officials, and the general public, and consequently impractical at this time.)

5. Finally, there must be an objective presentation of these alternatives and the supporting evidence to the responsible decision-makers, so that they may make appropriate decisions with respect to selecting one of the alternatives for design and implementation. A legitimate outcome very well may be that no change is desirable.

TEAMWORK

While this process is straightforward in concept, it can be exceedingly complex and difficult in application. For example, the relatively simple task of analyzing the necessity for change in the curriculum of a school may require the attention of experts in subject matter, school administration, and audio-visual arts.

The experience of recent practitioners clearly indicates that a nominal interdisciplinary approach is inadequate. The individual scientist, engineer, and technician must become an integrated team - interacting in a common environment on a day-to-day basis with a common problem-oriented focus. The development of this capability is a hard-won, time-consuming, and a costly process. Not least among the difficulties in achieving a truly integrated team is getting scientists, technicians, and engineers from disparate backgrounds and disciplines to understand each other. The language and conceptual barriers are both large and real.

During World War II, the United States was faced with the task of solving technical problems of enormous complexity. To assist the nation with this problem, the best scientific and engineering talent available was called from the classroom and the traditional laboratory. As a consequence of this unprecedented concentration of scientific and engineering talent, in this country and elsewhere, came such systems as radar, ballistic missiles, and atomic energy. One of the least publicized results of this wartime effort was the emergence of a powerful new discipline - "operations research."

In the 20 years since the end of World War II, the United States has witnessed a continuous evolution and development of a family of technologies exemplified by operations research, management science, systems engineering, computer and information science, and an array of tools - such as linear programming, sensitivity analysis, cost-effectiveness analysis, decision theory, mathematical modeling, and simulation. While these technologies and tools originally were applied to problems in the realm of defense systems, they now are being applied to finding solutions to socioeconomic problems.

CALIFORNIA STUDIES

Late in 1964, California Governor Edmund G. Brown requested proposals from the California aerospace industry for the application of systems analysis to the public problems of information, criminal and mental illness, waste, and transportation.

As the contractors spread out over the state, gathering data and defining the problems, they did extensive surveys of previous studies, particularly the economic planning studies that already had been done. Two common observations came from all four contractors: nowhere did data exist in the form that was optimum for their purposes, and the topology of the problems did not fit the topology of the electorate. This, inherently, is the largest single inhibition to solving such public problems.

Each of these contracts resulted in a system description and an attempt at a refined statement of the costs and benefits to society for each area.

Information System: The information system study provides a design concept and a development plan, schedule, and costs for achieving the conceptualized system. This plan has a very real place in the history of the Californian efforts to maximized its return from the investment in information technology. A previous management study performed by the state indicated the need for such a long-range plan, and the state now is reorganizing and developing a staff for a new thrust in data processing which will be guided by this plan.

Waste Management: The waste management study demonstrated the necessity for considering all waste management within a single system. It made obvious the difficulty of attempting to consider this single study when there was no single agency responsible for the overall problem. Within the limits of time and resources, it was apparent that detailed consideration of anticipated waste loads could not be considered.

Most of the delay that can be anticipated is due to the necessity for completing the amortization of existing individual facilities before new facilities become economically feasible. A major recommendation was that of placing all statewide waste management problems within the purview of a single agency which would be newly established. It also was indicated that additional legislation would ultimately be required so that local or regional government units could be made to comply with the wider requirements of California.

Transportation: The transportation system study provided a program which can be expected to lead to a mathematical model of the complex transportation system required by the state in the future. Such a program includes the derivation of the effect of changes in living and transportation habits, changes in the mix of goods shipped throughout the state, and the effects of new technology. Information seemingly not directly related to the problems of transportation was shown to have an effect.

Crime and Delinquency: The six-month study of crime and delinquency may not have resulted in any startling new discoveries, but it did serve to point up, objectively, problems that cannot be easily ignored today. Furthermore, it pointed up these problems with techniques that would allow the authorities to determine the consequences of introducing changes in terms of the cost and effect on the operations of any part of the system of criminal justice.

The study indicates clearly that the increasing crime rate is not a result of a breakdown of social structure, but much more the result of a tremendous increase in the population within the age group from 16 to 29 years - the age group that contributes most heavily to crime in California.

The related collection of activities referred to as the system of criminal justice was well adapted to being examined through the technique of constructing decision networks and functional flow diagrams. The networks made it possible to identify meaningful boundaries, such as the limits of organizational responsibilities and the flow of information within the system, as well as the preliminary use of a common factor for evaluation (cost-effectiveness) throughout the system.

OTHER APPLICATIONS

Education: In the sense of our earlier stated definition, a university is a system. So is a school district. When viewed from the much larger perspective of national requirements, the total number of public schools, colleges, and universities in the United States represents a system of education. An analysis of this system would attempt to integrate interdisciplinary research findings, formulate alternative approaches in designing an improved educational system, and measure the costs and effectiveness of each approach so that comparative systems could be more easily evaluated in terms of their potential for realizing educational objectives.

Document Handling: While the capacity for executives, scholars, and scientists to absorb information has remained relatively constant, the amount of available information has increased by orders of magnitude. The growth in volume of information is matched only by the growth in the number of users. There is, therefore, a parallel need for a more precise capability to retrieve specific data and a more appropriate means to be found for storing and disseminating this information.

Urban and Regional Affairs: For the first time, to our knowledge, a massive analysis of the major problems facing an entire city was attempted in the late fall and early winter of 1965 in New York City. The purpose of the study was to provide then Mayor-elect John Lindsay with an organized description of the status and organization of the administration he was inheriting.

The study, which was conducted by System Development Corporation staff members, included a survey and analysis of the economic forces, health care, welfare, the school system, housing conditions, police functions, air pollution, and the structure and function of the mayor's office.

Long-Range Planning: Long-range, systematic transportation planning is urgent. This was recognized at the national level with the passage of the Federal Highway Act of 1962. The enactment of this law has led to transportation studies in many regions of the United States. One of particular concern is the Bay Area Transportation Study Commission (BATSC) in northern California.

The commission, created by the California Legislature in 1963, is charged with the conduct of a comprehensive transportation study and the preparation of a master regional transportation plan for the San Francisco Bay area - which is made up of the city and county of San Francisco and the counties of Alameda, Contra Costa, Marin, Napa, San Mateo, Santa Clara, Solano, and Sonoma.

POLITICAL PROBLEMS

At this point, it would be worthwhile to turn to a discussion of some of the important operational problems that have been encountered in the use of systems techniques.

One important problem concerns the disparity between the natural dimensions of a socioeconomic problem and political boundaries. For example, the sources and effects of air pollution or crime are not confined within the boundaries of individual cities, counties, or even states. Moreover, meaningful solutions require interjurisdictional approaches to such problems by means of Regional Compacts and Joint-Powers Agreements which allow coordinated action across traditional geopolitical boundaries and through various levels of government.

Another important problem is highlighted by the fact that each of the four aerospace studies resulted in a recommendation to undertake long-range programs in their respective problem areas.

A third problem involves the glamor that often surrounds the application of technology to new areas. It should be emphasized that the determination of objectives of a system cannot be left to the technologists alone. This must be a joint effort between the elected officials who are responsible to the public and the specialists who are attempting to develop the program. The purposes, uses, and goals of any program must derive from the values and mores of the public.

Another problem deals with the generalizability and transferability of the product resulting from the application of systems technology to particular problem areas. At least at the present stage of our capability, solutions developed to a problem in one geographic area are not likely to be wholly transferable. Rather, what will be generalizable is the experience gained by the analysts and the techniques and tools that they adapt from the defense effort or that they develop in pursuit of their tasks.

MANAGERIAL KNOW-HOW

It should be emphasized that systems analysis is not a panacea. It is not a black box into which one drops problems at one end and automatically receives solutions at the other. While the intent is not to detract from the value of all the knowledge and experience that can be transferred from the defense community, it should be recognized that problems of the civil sector are no less difficult, and perhaps are more so, and require the utmost creativity.

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One of the reasons that the four aerospace contracts look so promising is that these companies have applied some of their most creative people to the effort. It would appear that the contribution of managerial know-how from the defense community is at least as important as the contribution to be derived from the technology itself.

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